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ABSTRACT

Suggesting that neuroscience and the actualities of brain circuitry can provide guidance for what is misunderstood in writing education, namely, the role of subjectivity and values in the composing process, this paper argues that neuroscience provides corporeal evidence for the salience of particular brain structures and processes responsible for subjectivity. The paper discusses 3 fundamental human realities that lay the ground work for this claim: (1) the sociology of the brain; (2) the psychology of the brain; and (3) the physical brain--the public, scientifically observable and verifiable realm of the material being; the brain is tangible, its activities measurable. Sections of the paper also discuss Charles Darwin and language learning; the brain's selection processes that create the mind; higher-order consciousness and writing; primary consciousness; theory of neuronal group selection; memory and value; and language and values. The paper concludes that if writing instructors begin to understand brain anatomy and circuitry as partly hardwired and unconscious and partly amenable to conscious choice, they may be better able to appreciate impairment--writing problems may be emotional problems, situational problems, or biological problems that take various forms. Contains 58 references and 4 figures illustrating brain anatomy or models of learning processes. (RS)

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Values:
Understanding Written Language and the Mind Through Brain Biology

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Values

Understanding Written Language and the Mind Through Brain Biology

> Hope and belief are as important in science as they are elsewhere; the difference is that in science they must yield to experiment.
>
> Gerald Edelman

Current thinking about the writing process exists at the intersection of the twin constructs of cognitive process and social construction, namely, social cognition. Both, by now, are comfortably mainstreamed. Perhaps writing specialists are satisfied that we have achieved theoretical balance. However, these theories allow us tacitly to detach the mind from the reality of our brain, to attribute human thought to intellectual discourse communities (Bruffee, 1993; Flower, 1994; Woodmansee & Jaszi, 1995; Bereiter & Scardamalia, 1987). Removing the mind from the body overemphasizes our tilt away from the mind's physicality.

It is perfectly appropriate for neuroscience to account for our most profound and unique characteristic, the workings of human language and thought. But because rhetoricians and compositionists are not formally trained in the natural sciences, it has been inapt for them to examine brain theory and research for its impact on the discursive mind, except as a tantalizing hook for discussions on language and rhetoric: Emig (1978) on the split brain and trauma, Hogge (1985) on surface errors in writing and hemispheric deficiency, Glassner (1982) on the EEG amplitudes and hemispheric arousal, Shook (1981) on lateralization and education, and Winterowd (1979) on the brain and style.

Like composition studies, brain biology has over recent decades become more interdisciplinary, drawing on linguistics, the social sciences, hermeneutics, and philosophy. It has also become more humanistic--more holistic, natural, and relativistic. The idea of discourse communities is therefore not at odds with a biological model. On the contrary. We recognize that language is socially constituted. We process language in our mind. And the brain constructs it. It is thus no coincidence that brain biology broadly parallels social cognitive theories of writing.

The objective of brain science is to determine the relationship between the brain and the mind. By tracing the mind from its ancestral state to a derived, value-laden brain brain structures, I wish to redress this bias toward pure social cognition with the current theories and actualities of brain circuitry. My aim is not to present a comprehensive biological basis for human mental events but to argue for a more accurate understanding of writing and higher-order thought through a contemporary biological perspective. Specifically, I claim that what is misunderstood in writing education, namely, the role of subjectivity and values in the composing process, neuroscience and the actualities of brain circuitry can provide guidance for. Neuroscience provides corporeal evidence for the salience of particular brain structures and processes responsible for subjectivity, without which there would be no mind, much less language.

Although the mind sciences are far from new, the

physiological workings of the brain have become more accessible to the educated public (Restak, 1993; Sacks, 1993). I no longer need to continue in composition studies without some understanding of brain theory. I need not relinquish the discoveries I have made that confirm my intuitions about writers or disconfirm my own sense of my biology as I watch myself age. A subsidiary goal in this essay is to spark the interest of writing specialists--veterans as well as the newly initiated--who are not usually in the business of caring about our mental biology, to come to grips with it with more confidence and less intimidation. Neuroscience thus lets us talk in a different way about the mind, enabling us to revisit writing process theory with new knowledge from brain biology.

To lay the groundwork for my claim, I want to distinguish three fundamental human realities:

1. The sociology of the brain. Interpersonal dynamics whose origins occur outside the brain among individuals and groups but whose meanings are not necessarily verifiable; psychologically lawful but not necessarily logical; a medium through which we all navigate daily without necessarily acknowledging its assumptions;
2. The psychology of the brain. The inherently private realm of the mind; the intrapersonal conversation between the I and me;
3. The physical brain. The public, scientifically observable and verifiable realm of our material being; the brain is tangible, its activities measurable.

Sociology of the Brain

The most striking characteristic of contemporary brain theory is its representation as a neural econiche. The brain may be viewed as social cognition incarnate. Neural activity is situated and interdependent. At the biological level it is "only through interactions with the world that appropriate [or inapposite] response patterns are selected" (Edelman, 1992, p. 226). Neurons undergo continual transformation because of such interdependence. I do not refer to a sociology of norms, roles, the self but to a sociology of circuitry, cell adhesion, chemical baths, and electrical firings. The role of social factors in writing has thus special meaning here because the social factors happen to be anatomical structures not human groups. I am also not referring to whole brain activity. Nor am I referring to a single neuron--a whistle in the wind. Rather I mean *clusters,* regions of neurons. Such dynamics recognize the contingent nature of the surroundings of the brain at any given time, its multiple and overlapping neural communities.

It is nothing new that a brain changes itself in response to consistently administered stimuli, because that's what neurons do: they have vast opportunities for change; they constantly learn and relearn; and particular circuits strengthen while others weaken. Bodily experiencing creates experienced meaning. From this neural education evolves complex sets of sociocultural and linguistic propensities.

Psychology and the Brain

The second basic human reality, the psychological component

of social cognition, is typically represented in education by individual intellectual processes and broad values. It is with similar conviction that current neuroscience mounts its case for neural individuality. The reasoning is that our brain connections are not entirely fated, not preordained by genetic plan. Of course, we cannot divest ourselves of our physiological history, our biological imperatives, including our biochemistry. Nor can we ignore the nonnegotiable patterns of cognitive behavior that shape human discourse (e.g., perception, imitation, memory, symbolizing).

But at another level of analysis the mind is always unique. The venerable coupling of cognitive models of the mind and information processing systems produced a story that Turing once audaciously asserted that were someone to specify the ways in which humans are superior to computers, he could build one refuting that belief (Popper & Eccles, 1977, p. 208). Contemporary brain theories challenge that. The social and neuroscientific answer is that even if such a machine were possible, the mind could not be created even if every neural connection was reproduced faithfully (Zajonc, 1992, p. 13).

> The existence of irreversibility, uncertainty, high density, and novelty would still preclude construction of an appropriate set of computational abstractions. There is no effective procedure by which *all* possible events and relations in a world consisting of the interacting conscious animal and econiche can be represented in a computer or a

Turing machine. (Edelman 1989, p. 258)[1]

The mind sciences and the cognitive model of writing, for example, both celebrate cognitive lawfulness without precluding individual empowerment. We have the anatomical potential to conceptualize, imitate, remember, symbolize. While cognitive theory recognizes our debt as a species to evolutionary biology, contemporary neuroscience privileges infinite uniqueness, choice, and change.

What's more, the idea of individuality introduces an element of idiosyncrasy. For example, when we look at similar things, we isolate comparable elements, which usually involves shifting emphases. But shifting emphases among objects is highly negotiable. What starts off as a mere movement of a gaze becomes idiosyncratic, an act of interpretation. We don't distort or misrepresent willfully. We merely perceive things differently. Contemporary neuroscience disrupts the notion of a discourse based on pure ratiocination, without anything involved as unpredictable as interpretation or as idiomatic as subjectivity (Brand, 1989). It is "[t]hrough the interpretation of experience [that] the conscious self subjectively constructs reality" (LeDoux, 1985, p.208). There is no subjectivity-free human observer (Edelman, 1992, p.114-115). Putting ideas and things into words necessarily gives rise to subjectivity not only because it is filtered through our personal brain, but also

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[1]Maps of brain tissue demonstrate infinitesimal differences even in brains of identical twins reared together.

because it involves preference and choice which our personal brain gives rise to. Indeed, subjectivity is precisely the attribute that gives human life meaning. Echoing her mentor, philosopher Suzanne Langer, Ann Berthoff (1981) essentially anticipated this long view when she argued that interpretation is a branch of biology.

This brings us to the mind as a physical entity. To believe in the mind is also to believe in its biological reality. If we in any way trust neural evolution, we have to take the body as beginning.

The Physical Brain

Each hemisphere of our brain was considered virtually identical until language began to develop 40,000+ years ago and speech emerged. Despite the rudimentary language of chimpanzees, true language is still considered a singular human phenomenon. "[S]ince language and cognition probably represent the most salient and the most novel biological traits of humans...it is now important to show that they may have arisen from extra-adaptive mechanisms," those not necessary for phylogenetic survival. In other words, while humans are obviously born with the potential for language, "language and cognition are acquired skills that come about by learning" (Gazzaniga, 1992, p. 9). To be sure, writing and higher-order thinking are the end of the adaptive process as we understand it. Obviously, evolutionary theory also invites us to look at the beginnings.

The Central Nervous System. Phylogenetically, the mind developed

from a new morphology or form and structure of the central nervous system. It is made up of the spinal cord and brain, a three-pound mass of 12 billion neurons[2], fifty percent of which can regenerate (mostly from the back of the head) until we are about eight years old (Restak, 1993; Springer & Deutsch, 1981, p. 206).

Components of the Brain. The major divisions of our individual biological mind parallel the evolutionary ascendancy of the vertebrate brain. The spinal column arose from the infolding within the body of the earliest sensory organ, the skin. From bulb-like projections at the upper end of the spinal column emerged the limbic lobe, the proto brain or transitional cortex, and the forebrain. The *hindbrain* is part of the brain stem and spinal column and, as such, is the most ancient part of the brain. It houses much of the reticular formation charged with our nonspecific states of alertness, arousal, and gross adaptive behaviors. The hindbrain controls the organic/autonomic[3] (respiratory, circulatory, digestive) systems and excitory behaviors and converts general decisions into basic muscle or motor commands.

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[2] The brain of an infant is about 1/4 the weight of the brain of the adult. By the time a child is 2 years old, the brain has tripled in size and is almost its adult size (Springer & Deutsch, 1981, p. 131).

[3] Although far more complex, the autonomic nervous system controls involuntary actions, smooth muscles, and glands and includes the sympathetic and parasympathetic systems: The sympathetic division is concerned with arousing recuperative, restorative, and nutritive functions; the parasympathetic is concerned with inhibiting them.

The next and smallest section of the brain is the *midbrain* (sometimes considered part of the upper brain stem). It is made up of the remaining reticular formation and primitive sensory centers developed to perceive from a distance (Heath, 1986, p.5; Penrose, 1989, pp.380-2). Both hindbrain and midbrain control the unconscious or automatic aspects of behavior.

Insert Figure 1 About Here

The newest and largest section, the *forebrain or cerebrum*, is divided into four lobes (occipital, parietal, temporal, and frontal[4] or two cerebral hemispheres that are linked by the cable-like neural fibers of the corpus callosum and the hippocampal and anterior commissure (see Figure 1). The forebrain itself evolved from a primitive but crucial limbic organization to a transitional cortex. From this transitional cortex came the associative, interpretive, or uncommitted neocortex whose neurons respond in profoundly intricate interlocking and looping relationships. Covering the surface of the cerebral hemispheres is the outer layer of gray matter, 60% of which constitutes the neo or associative cortex, and 40%, specific motor and sensory regions.[5] All in all, an estimated 108 billion cells[6] reside in

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[4] The prefrontal area makes up 1/4 of the total brain mass (Luria, 1973, p. 88).

[5]The cortex generally refers to the neocortex and hippocampus. The subcortex refers to the rest of the central nervous system, including the spinal cord. The sensory and motor systems have cortical and noncortical counterparts (Oakley, 1985,

the brain--not to mention the 10^{15} synaptic connections between them.

In the deepest recesses of the forebrain sit the thalamus, hypothalamus, hippocampus, and amygdala, part of the relatively hard-wired structure of the proto or reptilian brain called the limbic lobe.[7] I want to talk for a moment about the limbic lobe. For a long time declared the anatomical basis of affect (Papez, 1937), the limbic lobe was buried and preempted over time by our associative cortex whose circuitry extends from various outlying and internal bodily sources to the hypothalamus, thalamus, hippocampus, and cortex and then back (LeDoux 1989, p. 268). The limbic lobe interfaces the midbrain and frontal lobes, where it processes tactile, visual, and auditory information. But the limbic lobe of the brain has been best known as a hedonic center, involved in such rudimentary but crucial emotional reactions as approach and avoidance which are in many respects as affective as they are organic. The associated experiences of hard-wired, organic emotions like smell, taste, hunger, thirst, sex, fear, rage, and pleasure helped establish the molar nativist principle that organic meant adaptive.

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p. 135).

[6]This figure is derived by multiplying twelve billion distinctive neurons by 9 glial cells for each neuron.

[7]There is some dispute over which structures belong to which parts of the brain. For example, LeDoux questions the structures belonging to the limbic lobe (1993, p. 70). Heath places the thalamus and limbic lobe in the midbrain (p. 5). Edelman calls the hippocampus a cortical appendage (1989, p. 119+). Oakley places the amygdala in the base of the temporal lobe (p. xv).

For many years the conventional thinking was that our reticular system aroused, our limbic system "felt,"[8] and our neocortex, the thinking part of our brain, controlled.

Cerebral Hemispheres and the Localization of Language. Unlike higher-order thought generally processed all over the associative cortex, uniquely specialized in the human cerebral organization is language. Briefly, the left hemisphere is concerned predominantly with symbolic and propositional abilities: syntactic, semantic, mathematical, and logical. The right hemisphere processes geometric drawings and controls pictorial and pattern sense in a Gestalt manner. Such asymmetry is apparently inborn. This was empirically confirmed when scientists discovered the localization of language by studying brains damaged by trauma.

In the 1860s Broca and Wernicke identified two small but powerful parts of the left forebrain, wherein language abilities were organized into subsystems (see Figure 2). Although Broca recognized the cerebral asymmetry for language, he is remembered for his work on the region that *forms* sentences. In a nutshell, Broca's area transmits speech regardless of handedness.

Insert Figure 2 About Here

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[8]Recent research places responsibility for affective processes squarely with a small limbic lobe structure called the amygdala (LeDoux, 1993 ; Brand, forthcoming).

Wernicke's research identified areas in the temporal and parietal lobes that *understand* language.[9] The permanent representation for sounds of words are stored there. The auditory presentation of language in the parietal lobe stimulates "a concept center" (diffusely represented in the associative cortex) and is transmitted to Broca's area for speech in the lower rear frontal lobe.[10]

Representing a departure from localization models of the brain were holistic or molar theories that envisioned the brain as a single, integrated unit supporting all language functions. The molar perspective on the brain hypothesized by Pierre Flourens in the 1800s resurfaced through K.S. Lashley (1929) in the 1930s and 1940s (Caplan, 1992, p. 433; Rosenfield, 1988, pp. 12-13). Influenced by faculty psychology, psychology, cellular physiology, and neuroanatomy, Lashley's ideas about mass action and equipotentiality proposed an equal contribution of all regions of a given neural area to carrying out brain functions. His equipotentiality theory claimed that all parts of the brain had a similar capacity for performing a psychological activity, which he called mass action. Isolated deficits in language could not occur; a deficit in one area of the brain made an impact on

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[9]Caplan (1992) reports on aphasia studies that update Wernicke's work.

[10]Damage to Broca's area impairs the ability to speak fluently, but comprehension remains in tact. Damage to Wernicke's area does not disturb speech production, but what there is left of it generally makes no sense. When the connecting nerve bundles are damaged, comprehension and speech are not impaired, "but comprehension cannot be vocalized" (Penrose, 1989, p. 378).

all areas.

In the 1960s neurosurgeon Roger Sperry's split brain research led him to postulate two separate minds or a double consciousness. Justification for hemispheric differences went something like this: Brain specialization in humans is due to the unique demands made by language and spatial or pattern recognition during evolution. The increasing demand on hemispheric space could be in part[11] met by "eliminating the redundancy of bilateral representation, and having some separation of functions" (Popper & Eccles, 1977, p. 353; Sperry, 1985). Ergo, lateralization.

Although around the same time A. R. Luria (1973) stated that the "principle of lateralization of functions [had] naturally become a new and decisive principle of the functional organization of the cerebral cortex" (p. 77), as it turned out, contemporary neuroscience has challenged both the half brain and the two or redundant brain theories (Popper & Eccles, 1977, p. 353; Corballis, 1980, pp. 285-289; Bogen, cited in Caplan 1980, p.315). Neither model is adequate. While there is some protective duplication, there is also transfer between the hemispheres, indicating neither a two-brain model of cerebral organization nor an inexorable hemispheric specialization. Moreover, using a different region of the brain, the brain could actually relearn certain activities. If part of the cortex was destroyed, another

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[11]In other words, bilateral representation and the separation of brain function was necessary but not sufficient.

part could assume that function. This has been repeatedly borne out in research.[12]

Over the last half century or so, Luria reconciled both the localizationist and globalist positions by hypothesizing *modular* brain interaction. Overall, as the brain regions ascend, Luria found a shift from simple to complicated processes within pyramidally arranged cortical zones. He also found a decreasing specificity (p.74) and an increasing lateralization with close participation of speech (pp. 75-79). Some functions were localized, but the brain also worked as a whole to produce broad activity which could be organized hierarchically (Arbib, Caplan, & Marshall, 1982, p. 18). Luria applied the term, function, two ways: as a simple function involving one region, and as a complex function involving several regions (Kosslyn & Koenig, 1992, pp.

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[12] In terms of language, according to Kintsch and van Dijk, "the ability to abstract the major themes of connected discourse appears to be relatively preserved in many brain-damaged patients" (cited in Caplan, 1992, p.400). In other head trauma, some language can be recovered for a brain deprived of language (Popper and Eccles 310, 353). The right brain can take over some language functions if the left brain is removed or the corpus callosum severed (Gazzaniga & LeDoux, 1978, p. 62; Popper & Eccles, 1977, p. 324; Geschwind cited in Caplan, 1980, p.314). In still other cases there may be very little disability with speech because those particular muscles are already bilaterally represented in the motor cortex (Popper & Eccles, 1977, p. 298).

Furthermore, while it is true that the right hemisphere that is deficient in verbal expression *can* understand language, linguistic ability can transfer when certain traumas occur at young ages when considerable plasticity exists (Popper & Eccles,1977, p. 333; Gazzaniga & LeDoux, 1978, p. 62; Sperry, 1985). The brain seems to adapt to damage, so say neuroscientists, far more easily than we have believed. At best, language processes are now considered generally localized but still have considerable variation and potential (Caplan, 1992, p. 437-438).

11-12).

With that in mind, he postulated three functional units or cortical zones that anatomically recapitulate the Maslovian hierarchy of needs and anticipate current neuroscientific thought. The first functional unit is subcortical, corresponding to the upper brain stem (reticular formation) that regulates nonspecific cortical tone or alertness (Luria, 1973, p. 45). The second functional unit obtains, analyzes, and stores information and is located at the back of the hemispheres in the sensory-specific lobes: occipital (visual), temporal (auditory), and general sensory (parietal). At this level the brain receives from and sends various impulses to the periphery of the body. It creates percepts, transforming the direct physical events into synthetic and symbolic processes or perceived realities--with their attendant interpretations, imaginings, and so on. Progressive lateralization--linked to handedness and speech--occurs here (pp. 67-68, 73). The second functional unit is also multimodal. Its overlapping zones can respond to several stimuli at once and are the basis for the knowledge functions of the third functional unit (pp.78-79).[13]

Luria's third functional unit is the superordinate neural area (p.89). It is composed of the frontal and prefrontal lobes of the forebrain that are responsible for higher-order mental

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[13] The evolution of language has traditionally been thought to produce lateralized cerebral functions. New work with primates has demonstrated that the asymmetry of cerebral function may be independent of language and handedness (Hamilton & Vermeire, 1988).

activity. Conscious, goal-directed, rational, and organized behavior is processed here (p.101). This unit not only programs, regulates, and verifies mental activity (p. 43), but it also controls the work of the second functional unit. In addition, it participates in activating conscious speech.

Luria's work set the stage for the contemporary research of psychiatrist and neurologist M. Gazzaniga who advances the notion of the integrated brain whereby at each stage in developing language the hemispheres are "intimately associated and [work] in synchrony" (Gazzaniga & LeDoux, 1978, p.39); Steven Pinker (1994) of MIT's Cognitive Neuroscience Center, who explores linguistics and cognition; Joseph LeDoux of NYU's Center for Neural Science, demonstrating with the amygdala the neuroprimacy of emotion (1985; see Brand forthcoming); and Gerald Edelman's Neural Darwinism (1987), on which the remainder of this essay principally draws.

Darwin and Language Learning

Contemporary neural theories of language and the mind seem to lead from Darwin who enunciated evolution as the result of natural selection: variation, change, environmental pressures, and adaptation. While evolution may at times be the result of sudden, punctuated change, Darwin's original theory claimed it is the outcome of subtle, gradual change in a less than benign or harmonious environment. "Natural selection results in the differential reproduction of those individuals whose variations (read 'structural and functional' capabilities--their phenotype)

provide them and their progeny with statistical advantages in adapting to . . . change" (Edelman, 1992, p. 42). Literally, survival of the fittest. The key concept is selection. For it is this perspective that can inform the teaching and learning of writing.

Consider the instructional versus the selectionist models of human development. Instructional theories hold that we have no preexisting capabilities and are molded by the environment. "The environment instructs the organism to change" (Gazzaniga, 1992, p. 17). Particular structures and functions are needed to survive in particular ecological systems. This shapes the expression of both the organism's biology and its learnings. If the organism is able to supply them, it survives and then reproduces, passing the traits along to its offspring. If the organism doesn't have those particular structures and functions, it dies off.

When learning is "instructional," responses are specified in advance and imposed on a system. Analogously, students are given a vocabulary list to learn: to spell, define, and use in a sentence. They then may be asked to develop an essay based on that vocabulary. In this tradition, choice is minimal. Students are figuratively blanks, empties. At the extreme, learning is equivalent to pedagogical surrender. To do well academically, students must defer to their environment--namely, their instructors, their course of study, and so on).

Selectionists claim the opposite; evolution works by selection, not by instruction. This means that what makes species

the "fittest does not require *prior* explicit information ('instruction')" (Edelman, 1992, p. 74; see also Damasio). Selection is a "mechanism in which the product under consideration is *already present* [my italics] in the system prior to the arrival of the signal" which then activates it (Jerne, cited in Gazzaniga, 1992, pp. 30-31).[14] In other words, genetic structures supply the general raw material, so to speak, and those with the best raw material (or capabilities) for a particular environment survive (p. 18).

Here, certain bodily structures are favored by selection *because* of their functions. This increases adaptation, which in turn increases reproductive success (or fitness). For example, teachers proposing essay topics for students to write impose a certain curricular structure on them. However, students may be able to choose among topics. They also may be able to choose their perspective and genre--which may, in fact, increase their chances of success with their paper. And it goes without saying that the students, of necessity, impose a style on the product.

Of course, Darwin's influence is obviously not that clear cut. "Learning and evolution need not follow identical laws, selectionist or otherwise" (Pinker & Bloom, 1992, p. 471). Evolutionary theory teaches us that genetic change is accidental and random and validated by selection. And formal instruction is, of course, no accident. At this level, however, learning may

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[14] Most evolutionary biologists believe a trait must be genetic in order for natural selection to operate on it.

still be considered directed by selection factors, with the larger society favoring some changes over others.

In the last analysis, even though evolutionary selection may sometimes look like instruction at the molar or top-down level of organization (Jerne, cited in Gazzaniga, 1992, p. 30), it also operates from the cellular level, bottom-up. That is, as species we are generic humans. My point is that there is no generic human at the molecular level, especially in neural theories of the mind.

Brain's Selection Processes Create the Mind

Enter Gerald Edelman, Nobel laureate and chair of neurobiology at the Scripps Research Institute, in an ambitious attempt to unify biology and the psychological sciences by applying Darwinian principles to the brain. His theory of Neural Darwinism, he asserts, dispels purely mentalistic notions of the mind. Dismissed too are representations in our heads of the outer world in miniature. There is no more need for vague anatomical concepts of brain functions (e.g., bilaterality and handedness, global language centers, neural assemblies or firings); no more resorting to a homunculus (1987, pp. 44-45; 1993, pp. 27, 82, 226). The way Edelman avoids vicious circles and dead ends is through a brain theory that combines selectionist and molecular principles.

On the one hand (though greatly simplified), Neural Darwinism postulates that from among preexisting neuronal *groups* in the brain are *selected* external or internal stimuli that

enhance some neural circuits and suppress others which results in the socially constituted mind. On the other hand, in contrast to the lawfulness of whole populations, in infinitesimal degrees, recapitulating adaptation at the idiomatic and cellular levels, the evolutionary process takes place--not one that selects organisms and takes millions of years, but one that occurs by competition and selection among brain cells within individuals and during their lifetime (1987, pp.170-171; see also Mayr).

In a nutshell, Neural Darwinism postulates that from among preexisting neuronal groups in the brain are selected external or internal stimuli that enhance some neural circuits and suppress others. Having set up this line of thinking, Edelman accounts for language developmentally. I will trace it backward from the familiar and privileged position of higher thought.

Higher-order Consciousness and Writing

Formal education is, in a very real way, schooling in literacy. And, of course, literacy is not neutral. It is political and ideological, co-existing with systems of beliefs and values. We are not strangers to the construct of values. Given that we purport to teach things of value, students are expected to learn and remember things of value. By values here I mean the broad sense of worth, much like Krathwohl's (1964) taxonomy of the affective domain that places the highest order of value on appreciation, altruism, ethical principles consistent with democratic ideals (pp.184-185), or Perry's (1970) moral relativism, or psychologist Mandler's cognitive values which he

considers neutral except for negative ones (Brand, 1994). What these views suggest is that values emerge at the upper reaches of our mental maturity and are contingent on our socio-psychological environment. This is clearly in keeping with ecological models of writing proposed by social cognitivists and constructionists (Bruffee, 1993; Cooper, 1986; Flower, 1994).

Higher-order consciousness refers to values, imagination, creativity, and other mental states that we recognize as the mark of mature human minds. This level of brain activity categorizes its mental states, the thinking subject of its own acts or feelings (e.g., I know that I know.). We metacognize. At this level we can select what our mind concentrates on. We can plan, explore the environment, engage in voluntary, intentional, and extended action. We free ourselves from the constraints of real time. We can view mental images from the vantage point of a socially-constructed self. We recall the past, live in the present, and conjure up the future--all in all, recreate external experience internally. We live mentally on several levels at once. We sense, perceive, react, interpret, and communicate at the same time. But we don't directly know or experience them as such. Rather, we enjoy a unified state of consciousness from moment-to-moment, an integrated experience (Gazzaniga & LeDoux, 1978; Popper & Eccles, 1977, p. 495). Most important, language and social interaction are prerequisites of higher-order consciousness.

While higher-order consciousness has a history and a future,

it is also anchored in the present where it appropriates the workings of the primary consciousness, Edelman's remembered present.

Primary Consciousness

Just as true language is required for developing higher-order consciousness, according to Edelman, primary consciousness is necessary for acquiring language (1989, p.172). Primary consciousness has memory available to it but only short term, a sort of "present tense," the kind I infer in my one-year-old grandson and, say, pet dogs. What we call simple or animal awareness, primary consciousness means being wakeful and responsive but without a sense of self, past, or future.

Primary consciousness, in turn, depends on the prior evolution of brain centers dedicated to conceptual development. But language and cognition should not be conflated when considering early concept formation. Although it is clear that speech and thought intersect in writing, in the normal human brain the distinction between linguistic and nonlinguistic ways of knowing is not always apparent. But both are there. Given what research concludes about infants and lower animals, concepts first arise spontaneously but do not require a link to a speech community. There is thought and there is language (LeDoux, 1985, p. 206).

Where earlier developmental psychologists and Edelman part company is in his assertion that while early conceptual formation is not symbolic in our sense of the term, it does need another

order of concept--one that is grounded bodily: with perceptual distinctions between 1) subject and predicate (where our physical selves end and our actions begin), and 2) the self and the nonself (a physical self versus all other things) (1992, p. 125). What characterizes these kinds of concepts is the very absence of awareness of forming or having them. Advanced primates may indeed have "glimpses of self-consciousness." But without the tools of language, they cannot "generate a sense of experiential continuity that we so readily construct" (LeDoux, 1985, p. 211).

Nor do the earliest concepts depend initially on sequential presentation. Rather, according to Edelman, concepts associated with primary consciousness depend further down the neural ladder only on 1) *perception,* that is, recursive neural connections between conceptual distinctions and ongoing perceptual categorizing; and 2) *short-term memory* linking those past categories to values (1989, pp. 100, 245). These two functions emerge in the second Experiential selection phase and in the third Reentry phase, respectively, of Neuronal Group Selection--the heart of Edelman's model.

Insert Figure 3 About Here

Theory of Neuronal Group Selection (TNGS)

Intended to explain individual differences in language and mental development, Edelman's Theory of Neuronal Group Selection (see Figure 3) starts at neural rock bottom, so to speak, and

turns on three assumptions:

1. **Somatic Selection.** First, cell types, as genetically determined, guide their general location in the body (Sacks, 1993, p. 43). Only certain places have the right contextual cues and result in differential gene expression, which is what makes liver cells different from skin cells from brain cells (Edelman, 1992, pp. 57-59). Second, the possibilities of variety in neural networks have genetic *limits,* falling within "narrow windows of developmental time" (1987, p. 136). Among what becomes "uniquely specialized and genetically specified in the course of human neural evolution is a *potential* [my emphasis] for expressing [certain] linguistic functions" (Gazzaniga & LeDoux, 1978, p. 72). As we know, what this means for language instruction is that biology can't dictate what language we will speak. But it will determine whether we will develop any language at all, whatever the locale. And development of writing skills depends on the locale available to learners. This is little more than saying that it depends on environment, the neural *experience*.

2. **Experiential Selection**

The basis for this secondary repertoire arises from the *preexisting* selections made at the somatic level[15]. Beyond anatomical selection, our "ecological niche" and our perceptions--the first requisite for primary consciousness--guide if not

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[15] Edelman's example is based on the visual system. Elsewhere he extends it to consciousness and language (1992, p. 83).

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constructs our mind.

Recapitulating phylogenetic and ontogenetic processes, when presented with changes in the environment, we come to have choices and preferences. We select. Experiential selection has adaptive advantages of a kind distinct from that of Somatic Selection. Somatic selection refers to fluctuations caused *internally* in the neural environment. Consonant with constructivist theories of writing, experiential selection means that certain neural circuits originating as *external* preferences are selected out for use when persons live in particular places. Taken at its widest meaning, this produces adaptive behaviors by socio-cultural transmission. In the short run, by choosing our environment, we expose ourselves to new selections that influence our experience, and, in turn, our neural organization. In the long run, those preferences influence evolution.

But nothing happens without human perception. The world as we experience it depends on the ability to perceive it. Quintessentially primal and automatic, perception in some definitions refers to the internal discrimination of an object or event through at least one sensory modality. This separates the object or event from its background or from other objects or events. If subjectivity is introduced into the neural equation, perception may then be defined as a biochemical *interpretation* of phenomena (acted on by both cognitive and emotional factors) (Plutchik & Kellerman, 1986). In other words, in perception we sense something and interpret it simultaneously--which is where

Edelman positions himself. He uses perception to explain the biological basis of the mind at this second level, without which memory, motivation, learning, language and values cannot occur (1987, p.26).

Humans are pattern seekers and makers. In our first encounters with our world as infants, things and events do not come in tidy, prearranged files. We spontaneously categorize an unlabeled world (Edelman, 1987, pp. 24, 26, 41) and manipulate it as a consequence of particular neural adaptations. Developmentally, perceptual categorization is fundamental, unconscious, even often prior to sensation (1989, p. 265).

Language learning depends on the synaptic modifications of this secondary repertoire (Edelman, 1987, pp. 67-69). Every time we receive a stimulus or act on one we alter ever so slightly the synapses and therefore our neural circuitry. Analogous to Erving Goffman's social gaming, our neurons compete for cortical space in contexts in which synaptic growth occurs (1987, pp. 45-46, 179; Donald, 1991, p. 380). Neural circuits frequently stimulated in a particular econiche are more likely to be selected again (1987, p.46). These neurons exhibit more and thicker branching, and the synapses, the primary mechanism of this secondary repertoire, grow stronger[16] like muscles or babies.

Further, while skin cells cannot become brain or heart

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[16] Something as minuscule as the structure of (neural projections) and the strength of cell glue (CAMS)--(cell adhesion molecules discovered by Edelman (1989, pp. 73+))-- may well cause us to categorize things in a slightly different way (Levy, 1994, p. 68; Rosenfield, 1988, pp. 173-174).

cells, the brain is still opportunistic. Under the right circumstances, it may recruit structures that have "evolved in one context to carry out different...tasks" in another (Kosslyn & Koenig, 1992, p. 441). These synaptic clusters form "functioning circuits in maps" (Edelman, 1989, pp. 41-42). Some map plasticity is not limited to short critical developmental periods. Other maps are, as in the visual cortex (1987, pp. 133, 136). Changes in maps or circuitry occur most readily at these times. Perceptual categorizing must be in place and ongoing for the memory and learning of the last process to occur, reentry signalling (1987, pp. 242+, 296; 1989, p.152).

3. **Reentry Signalling**

In theoretical terms it is in this third and most complicated phase of Neural Darwinism that memory originates. But Edelman's construct of reentry is not the same as associative networks, cell assemblies, neural nets or webs, or artificial intelligence circuitry (Levy, 1994, p. 69). Nor is reentry the feedback that suggests fixed paths as in information processing models of writing. It is profoundly recursive and profoundly idiographic, far more than composition theories have been.

And one way it occurs is via a small gap between the synaptic cells. Signals *trip* release of chemicals at the tip of nerve fibers. Electrochemical "retrograde messenger" molecules strengthen the synaptic link because not only do they connect to the receiving cell, but they also return to the sending cell, thereby reinforcing the connection (like doubling thread when

sewing on a button). This is reentry in general biochemical terms (Wheeler, 1995).

In order for stimuli to double back on themselves a first level of mapping must be in place. As I noted earlier, the autonomic centers responsible for basic adaptation and survival produce the first reentrant maps by converting sensory input into subjective events according to the hedonic meaning originating in the limbic lobe. This creates the first biochemical value system. Our internal life is further created through direct communication between the limbic lobe and the cortex (Edelman, 1987, p.25; 1992, p.120).

When combined with perception, the cortex begins to register motor and sensory stimuli. By creating perceptual categories, these regions form the primary sensory areas. From the biochemical signalling between neural maps continually emerge new and elaborated neural arrangements that respond to every language event, no matter how minuscule. Over time, the neural brain "remembers" past categories through its synapses, corresponding roughly to what Vygotsky (1978) recognized as the unrefined or natural memory of perception (pp. 38-39). The cortex accrues an anatomical "history" where early memory begins, that is, autobiographical memory before the age of three or four years (Brand, 1994).

To prepare for semantic activity and writing, the brain needs to remember the order of doing things. Building on the natural human ability to carry out actual perceptual sequences

and ordered behaviors is Edelman's "presyntax." Presyntax accounts for a special sort of nonverbal, mental chaining of events that places objects and actions in temporal or spatial sequence (e.g., see, then reach for) (1989, pp. 112-114, 147). Distinct from grammatical syntax but similar to the formation of *perceptual* concepts, presyntax occurs not with linguistic symbols but with an implicit, embodied awareness (procedural knowledge and memory). Because presyntax eventually extends to the ability to string syllables and words together (allowing verbs to follow nouns, objects to follow verbs, etc.), Edelman contends it provides a behavioral metaphor for linguistic thought (1989, pp. 147-148).

Neural Darwinism postulates continual transformation of our biophysiological processes during the Experiential and Reentry phases of language and mental development. With the emergence of the vocal tract and accompanying speech production, organic and observational learning as well as perceptual categorizing also prepare for the social transmission of language. Phonological or speech sound capabilities provide a mechanism for connecting categorized percepts to semantics. Through what Edelman calls *perceptual bootstrapping,* nonconscious conceptual categories (e.g., fire, flames, hot, hurt) are established in the frontal, parietal, and temporal cortices along with rough approximations of their corresponding language sounds. Concepts at this level are nonverbal and only broadly relational. They link perceptual categories to one another (e.g. hot <--> things <--> hurt), but

are richer than perceptual categories themselves because they involve some cognitive activity (1989, pp. 266-267; 1992, p. 108).

Inherently relational, language sounds rapidly become meaning laden. When reentrant connections are made with concept centers, *semantic bootstrapping* occurs (p. 134). By this is meant the architecture of meaning through a continuous series of progressively complex cognitive phases. The successive generalizing of phonemic and symbolic memory provides the neural foundation for sequences (syntax) of articulated sounds to make new meaning (1989, pp. 188-189). Put another way, as vocabulary builds and sentences form, categorizing their organization results in syntax or a full-blown grammar (1992, p. 129). In short, experience is rendered into words. True speech results in an enormous amount of conceptual power because symbolic learning emerges (p.130). With semantic bootstrapping and memory, the work of the world and higher-order thought is built (pp. 125, 132-134) (see Figure 4).

Insert Figure 4 About Here

Memory and Value

As with Darwin, I have invoked Edelman as a heuristic for understanding the sociocognitive model of the mind. I have tried to show that social cognitive theories of language have a neuronal counterpart. I have noted the constructs of subjectivity

and values that have a scientific counterpart typically called, affect, emotion, or feeling. But a case cannot be made for subjectivity per se from Edelman's work because hardly a word on the subject appears in it. The answer to the question may be found not only in Darwin's (1872b) theory of the universality of emotions in man and animal (which is beyond the scope of this essay) but also in contemporary brain research where subjectivity and values are identified as emotion and studied under controlled conditions (LeDoux, 1993).

Although higher-order values are not usually subject to empirical verification in the normal sense of the term, I wish to make something clear. Because the term, value, spans the brain and the mind, it still is a significant "border-crossing concept" (Modell, 1993) shared by science and the humanities. To be sure, higher-order thinking is the end of the adaptive process as we understand it. Evolutionary theory invites us to look at the beginnings.

When I talk about values from the perspective of brain biology, it becomes immediately clear that the transcendental idea of values first manifests itself biologically. The first crude value system is established in the phenotype. Evolutionary biology assures us that our basic needs are taken care of first. These values are biologically fixed in the neural regions of the brain concerned with regulating bodily functions in ways that satisfy our "homeostatic, appetitive, and consummatory needs reflecting [sic] evolutionarily established values" (Edelman,

1992, p. 100; 1989, pp.93-94)--put simply, the basic survival impulses to stay alive, to avoid what is bad, to approach what is good. Thus forms our basic value system, what physicist Pugh calls primary values. "Although we [do] not choose our innate values we certainly do make choices in terms of those values" (1977, p.159). Nonetheless, only when our lower physiological and safety needs are satisfied can our uniquely human values of self-esteem, social esteem, creativity, and, in the words of Abraham Maslow, self-actualization be sought.

Given the transcendent and biophysical definitions of value, it is not difficult to see that the mind and written language arise from special relationships among brain anatomy, perception, concept formation, and memory that embrace both scientific and humanistic perspectives. The progressive differentiation (elaborations and refinements of neural networks--more capillaries and more connections between neurons) of particular brain structures (frontal lobes, limbic lobe) takes us from elemental impulses to higher-order attitudes and values.

Social cognitive theories of knowledge, as viewed through an evolutionary lens, show how the first, vague, tentative percepts emerge and gradually refine our model of reality (Sacks, 1993, p. 48). This is why writing may be considered not only a social object but also a vehicle for knowledge, with its ineluctable dynamic toward meaning--which, I must add, our value or interpretive system continually mediates.

Written language and complex cognition occur in relation to

a memory system that acts on distinctions in values made through two limbic structures (Edelman; 1992, p. 117; LeDoux, 1993). The first is the thalamocortical system made up of the hippocampus responsible for memory, contextual information, and cognitive mapping (Kosslyn & Koenig, 1992) and the associative cortex. The second is the amygdala of the limbic center, which evaluates the significance of stimuli--like subjectivity, yet another euphemism for emotion.

Be that as it may, a developmentally early cognitive structure in the limbic lobe, the hippocampus has long been identified as a modulator of *social* behavior. The right hippocampus is dedicated to constructing maps of the physical environment. The left hippocampus is considered responsible for the semantic maps that store verbal material and manipulate narratives and relationships among abstractions. Both adjust for human context. The hippocampus thus has major social cognitive functions.

The amygdala acts a little differently. Information flows into the amygdala from the cortex after the cortex completes a meaning analysis of the information--which squares with cognitive theories of the mind (Mandler, 1984). However, information also flows into the amygdala from regions that *bypass* the cortex altogether, making those circuits work faster (LeDoux, 1993). The amygdala also matures earlier relative to the hippocampus and cortex and that same information is independent of consciousness. When the emotional tone of an external stimulus is dissociated

from the conscious cognitive content of stimuli, persons may be unable to state what the stimuli are, which is a cognitive skill, but they are able to access how they feel about them. What is most interesting is that humans can carry out tasks without a hippocampus but not without the amygdala (Mishkin & Appenzeller, 1987, pp. 87-88), the veritable seat of subjectivity--feelings, attitudes, interpretation, and values. Put simply, the hippocampus may keep cognitive processes alive. But the responsibility for affective processes lies squarely with the small limbic lobe structure called the amygdala (LeDoux, 1985, p. 205). The amygdala is the key to emotion without which the cognitive process of written language cannot truly function (LeDoux, 1993).

Some of these insights are quite in keeping with what we know about language: that activities of the brain recapitulates social cognitive theories of language; that brain theory makes for a better understanding of them; that language production and comprehension is not based on pure ratiocination. The brain constructs itself in the interplay of dispositions and stimuli (genetics and circumstance). While we cannot divest ourselves of biological imperatives, experiences activate and help create a mental ecology for future experience.

Language and Values

While references to emotion are few and casual in contemporary brain biology, it does tell us that written language and values are intimately coupled because both are products of

emotion.[17] Given the history of cognitive science, it is not surprising that the idea of value has been introduced without alluding to its root term, emotion (Mandler, 1984). How individuals feel as part of what they know is an important piece of information for, for example, students and instructors alike. What compositionists seem blind to is that feelings are reasons for deciding to do one thing or another. For all intents and purposes, every word we use is a decision and is thus value-laden in the most elemental sense (Saussure, in fact, makes the point that values and choice are virtually synonymous). What is needed in composition studies is an epistemology that links values and feeling with choice and decisions and discursive reality. For the stunning fact is that emotion is the key to writing at every level of acquisition and use. Some writing specialists just prefer to call it something else.

And that too is one of my points. Social cognitive theories of writing represent only one vision of the human mind. It is dangerous to ignore other dimensions. Cellular physiology, biochemistry are just two other views of it; the same picture, so to speak, different lens. The human language process does not change. Of course, while it is inappropriate to consider human thought and emotion as mere physical events, it is equally incorrect to hypergeneralize from the microscopic nerve world to

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[17]Mishkin and Appenzeller (1987) claim that because the amygdala and hippocampus have "co-equal" roles in memory, it may explain why emotionally charged events make a disproportionately large impression on us (pp. 82, 88)--which is why we use them to prompt speaking or writing.

full-blown human language. Writing is an act of the human mind not the brain.

Although nonlinguistic processing is generally overshadowed in consciousness by linguistic coding, its role in our mental life is without equal (LeDoux, 1985, pp. 203, 206). Our capacity for discourse does not obviate our prelinguistic, ancient ways of knowing. They are present and integrated into the activities of both hemispheres. What's more, when we are less vigilant or under pressure, the root brain with its basic impulses seems to take over. I liken it to diction levels. In formal professional situations I may use an erudite style to explain something. But should I not make myself clear, I can always revert to the one-and-two syllable plain style associated with children's talk.

This is in a sense why sensory experience is the quintessential starting point for teaching and learning writing (Hillocks, 1986). Because we can always return to a more elementary starting point. We take in data from our senses. We perceive categories and sequences. We remember them, combining them with our memories about what we experience. We formulate ideas and words to share this information. We undertake a reality check for mistakes.

Contemporary brain science tells us that we can shape our minds, individually and in our lifetime. Although the outcome of selection is not heritable across generations, experiential learning does do something to our heads. Choices are made, consciousness is realized, and language is learned and altered

again and again. Students bring to even the most routine tasks great creative potential. Maybe there's the rub. Under classroom conditions writing tasks and expectations have remarkable uniformity. The commonplace is acceptably safe, while much of our best verbal expression, for example, comes from what is idiosyncratic. School makes progress in writing standard when it is not. In this respect Neural Darwinism is plainly disappointing, because it says that we can never know the exact brain circuitry of any human. While human discourse per se does not occur at random, it is in the nature of humans to bring along with them considerable unpredictability; we don't often know how our students are going to turn out.

As for the receptivity of writing specialists to brain physiology and Neural Darwinism, I realize that to link neurocognitive decisions with social cognitive ones and then to suggest that language and neurobiology come together at values may come as a surprise. After all, it is difficult to trust what we don't know, much less figure out. We agree that the cortex plays a role in goal-directed activity. But it may be difficult to believe that a goal is never emotionally indifferent. It may be equally hard to believe that goals--let alone values--are neural, that self-preservation, the first law of nature, is emotional. We may agree that the rudimentary brain has survival functions. But that we still rely on those primitive structures is troublesome. When I say primitive, perhaps we imagine the digital simplicity of lower animals. This idea makes us

uncomfortable because cognitive science tells us that we are not primitive but sophisticated and subtle thinkers. Of course, just because primitive mechanisms play a part in learning is no reason to base our educational methods on them. The most useful learning nowadays is acquired, social knowledge--with its notions of observation, modeling, and correction.

It is within such a framework that new generations of teachers and scholars can set research agendas that, over the long haul, should influence policy and practice. If instructors begin to understand brain anatomy and circuitry as partly hardwired and unconscious and partly amenable to conscious choice, they may be better able to appreciate impairment. Writing problems are not only thinking problems. In fact, they may be thinking problems least of all. Rather, they may be emotional problems, situational problems, or biological problems that take the form of apraxia, aphasia, and dyslexia.

Instructors can change the way they think about enhancing memory by enhancing the emotions connected with it. How do the emotional differences among episodic, declarative, and procedural memory influence language acquisition? The profession can explore how certain kinds of talk help develop brains especially adaptable to symbol-driven societies. Brain science also has implications for metacognition, the awareness and control of one's thinking, including arousal and attention. Emotion dominates reason in many attentional decisions. Emotion guides how we divide our attention.

Brain biology should also raise awareness of the unique sensitivity of the human brain to experience. Every perceived interaction can have considerable and cumulative impact. We can sensitize students to how small shifts in language style can make enormous differences in purpose and rhetorical impact. Humans have the ability to evaluate. They become sensitive to words, style. There is a biological basis for the unique voices of our students, created, at bottom, by feeling--the defining attribute of human experience. Because students orient themselves, the locality of their selves, somewhere between the personal and their group memberships, the work of the brain becomes a means for them to preserve their ethnic, gender, and political identities.

It should be apparent by now that values are first not only emotionally real but also biochemically real before they are anything else. Social values are derived from survival values or biological emotions over the course of a lifetime. Social values are at par with higher-order thinking, whereas survival values constitute our organic priorities. We inherit temperamental biases. But we exert restraint. In his search for the neurocognitive correlates for language, Vygotsky sought to define nothing less than the etiology of complex human behavior, which originates as simple reactions to stimuli and slowly but inexorably comes under the control of the symbol-system of language. Clearly, as living organisms moved up the phylogenetic scale, humans became progressively freed from stimulus/response

sorts of functions. We became capable of turning potential values in the hedonic sense into actualized values in the broad, moral sense. And Neural Darwinism accounts for certain freedoms to choose our language, our knowledge, and our realities.

Therein lies the great survival value of the mind; we use our intelligence to promote our own intelligence (Gazzaniga, 1992, p.40). Pugh (1977) maintained that choice is only meaningful in a "context of preexisting set of values" (p. 159). Language and the mind as "value-driven decision" systems (p.173) may penultimately be explained through human phylo-and ontogenetic experiences. Such experiences are all about change and ever-present difference. The brain is an exquisitely resilient and labile system. It seems to me that the purpose of writing education is to provide steady and wide-ranging opportunities for students' growth in writing. They must do the rest. It is as simple as that.

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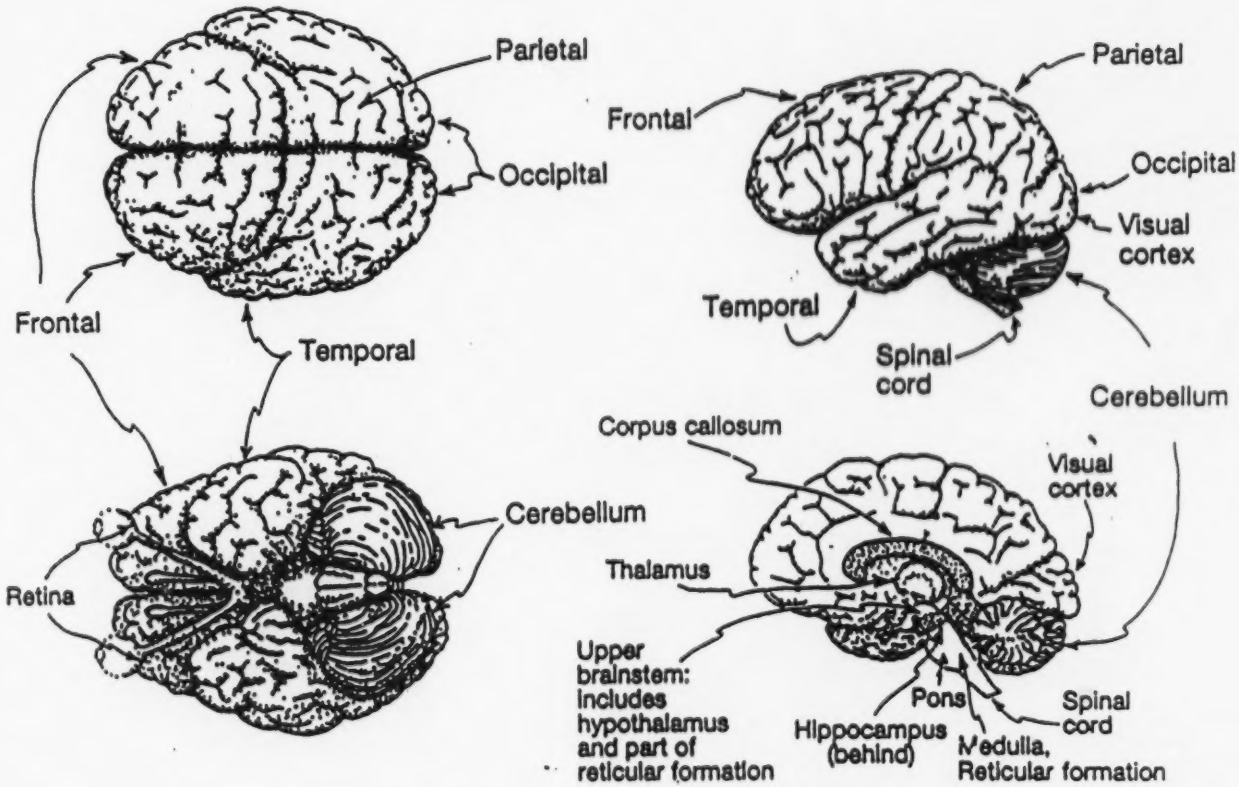

The human brain: above, side, beneath, split.

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Figure 1

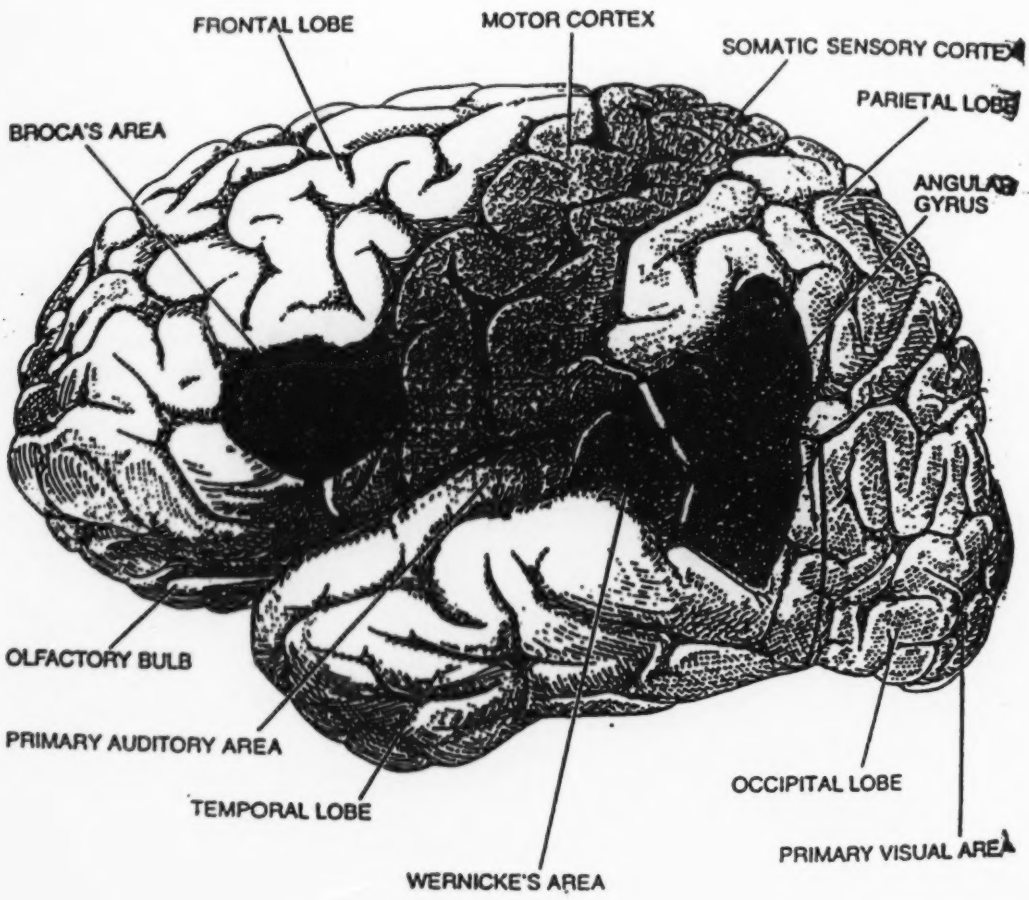

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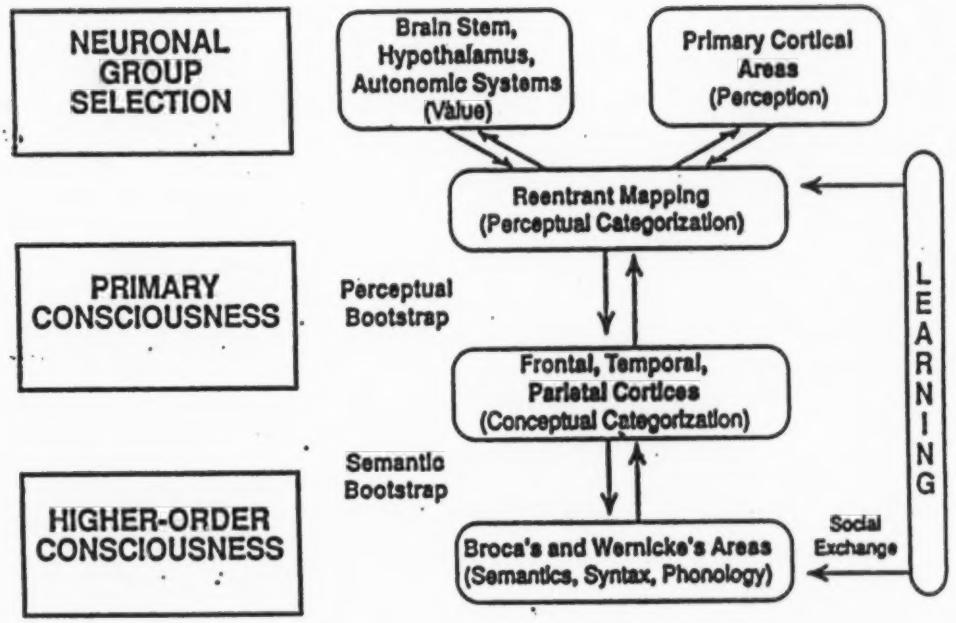
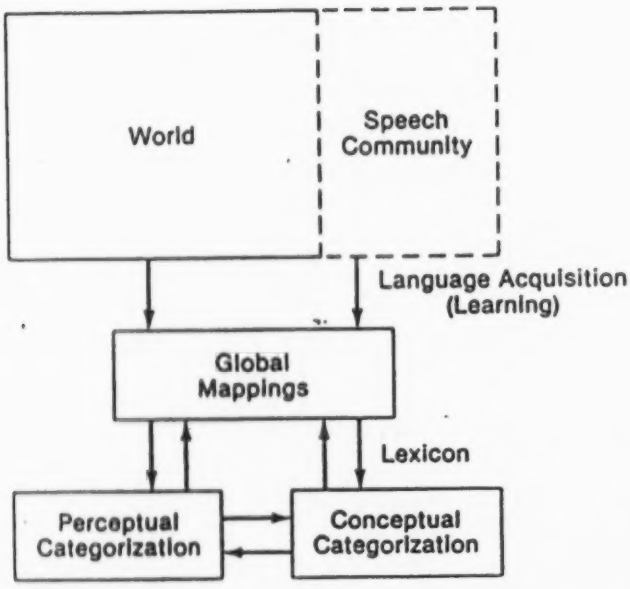
Figure 2



The Language Learning Process

Edelman, Gerald M. The Remembered Present. New York Basic Books, 1989. p. 241.

Figure 3



Neural Darwinian Model of Language Acquisition

Edelman, Gerald M. The Remembered Present. New York: Basic Books, 1989. p. 247.

Figure 4